J. Bequaert

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PSYCHE

VOL. XLVII DECEMBER, 1940 No. 4

AN EXPERIMENTAL STUDY ON CASTE DETERMINATION IN ANTS

BY LAURENCE G. WESSON, JR.

Boston, Mass.

There are two theories concerning the method of determination of the castes of the female sex in ants. The blastogenic theory maintains that the caste of the individual worker or queen is determined in the egg. The trophogenic theory maintains that the castes are determined by influences upon the egg or resulting larvæ after the egg has been laid. Between these two theories lies an ill-defined zone in which on the one hand environmental influences may be presumed to be transmitted through the reproductive female to the egg to alter the character of the nutritive material laid down for the larvæ, or even to alter the genetic pattern. On the other hand, it is possible that an inborn tendency to become one caste or the other may be only partial, to be altered under environmental stress. Definite proof of the blastogenic theory would appear to be a difficult task, and would probably require careful genetic and chromosomal studies. Certain proof of the trophogenic theory, on the contrary, appears much simpler and would consist in the demonstration that any arbitrarily chosen female egg can be caused at will to develop into either queen or worker through control of environmental factors. It is important to note here that failure to prove the trophogenic theory does not disprove it, for some potent environmental factor may still be uncontrolled.

Although no discussion of the arguments on both sides[1] will be attempted, it should be noted that no amount of experimental manipulation of environmental conditions has succeeded in producing morphological intergrades between queen and worker—only smaller queens and larger workers. Species do vary considerably, however, in the degree of variation transitional between the two castes, but always there is a distinct hiatus. Under natural conditions, each species normally has a certain season of the year, usually Spring or Fall, during which a portion of the female brood develops into queens. Further, it has been noted by numerous observers that the proportion of queens and workers produced at such times varies widely and shows a strong correlation with the economic conditions of the colony: the weaker and less well-nourished the colony, the smaller the proportion of queens and males produced. Obviously, there is some method by which the colony controls the time of appearance, number and proportion of the different castes.

In the past, practically every approach to the problem has consisted in marshalling general truths, analogies, bits of evidence in the way of field observations and anomalous specimens, and logical sequences by the proponents of one side or the other in support of their theory. For example, in the most recent of such engagements, Wheeler (1937), after careful study of a remarkable series of what were apparently queen-worker mosaics of the ant *Acromyrmex octospinosus*, came to the conclusion that the female castes are determined blastogenetically. Whiting, (1938), reviewing Wheeler's book, showed that these same mosaics could be intercastes and explained equally well on a trophogenic basis. Thus the solution is left as inconclusive as before, and it is apparent that only controlled methods of approach can decide. The only previous experimental approach to the problem which I have been able to find appears to be that of Ezhikov (1934) who writes: "When we subjected to hunger the larvæ of ants destined to be females (Camponotus, Myrmica) at different moments of their development, we never were able to obtain forms transitional between the queen ant and the worker, but either real fertile females, perhaps somewhat reduced in size, or else typical working individuals." In none of Ezhikov's publications which I have been able to examine have I found any further description of his experiments than is suggested in the above quotation.

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[1] Dr. Wheeler's book (1937) contains something of the various arguments, together with an extensive bibliography on the subject.

It is the purpose of the present paper to describe an experiment designed to test whether the castes of the female sex of *Leptothorax curvispinosus* are determined blastogenetically or trophogenetically.

Experimental.

The procedure consisted in subjecting two groups of larvæ, as nearly identical as possible, to controlled conditions differing between the two groups only in the amount of food supplied. During the summer, a quantity of larvæ (about 250) was collected from several nests of *Leptothorax curvispinosus*. These larvæ were thoroughly mixed, then introduced into a colony of *Leptothorax longispinosus* from which queen and brood had been removed. This was done to insure that no further *curvispinosus* larvæ would be produced. The resulting mixed colony remained about two weeks at summer temperature, during which time about 80 of the larvæ disappeared, presumably as a result of a certain amount of resistance to adopting them on the part of the *longispinosus*. The remainder grew a little. The nest was then placed in a cold room (2° C.) to hibernate. Five months later (March), the colony was removed from hibernation and immediately divided into two practically equal portions. In order to secure an impartial division of the larvæ, the smaller and shriveled specimens were discarded, the remainder gathered into a pile, thoroughly mixed together, then the pile was divided into halves through the center. At this time, the larvæ were 1/10-1/6 of pupation size. These two divisions may be designated colonies A and B, composed as follows:

Colony A—27 longispinosus workers; 44 larvæ.
Colony B—30 longispinosus workers; 44 larvæ.

Both colonies were maintained simultaneously under conditions as nearly identical as possible as to nest size and construction, feeding space, moisture, temperature and illumination, but differed in the amount of food administered.

Colony A was given a superabundance of food comprising egg yolk, sugar syrup, and grasshopper legs. Colony B was given the same kind of food, but just enough to allow the larvæ to grow. The precise amount of food to give to B was difficult to determine since too much would obviously defeat the plan of the experiment, while too little might cause the workers to devour some of their larvæ. As soon as each larva had pupated, it was removed and identified.

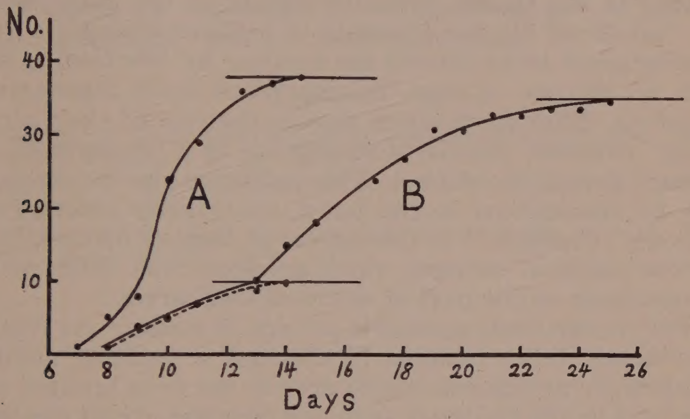
Results.

The results obtained from each group of larvæ are tabulated below:

	A	B
Larvæ initially present	44	44
Larvæ died during experiment	6	9
Larvæ surviving to maturity	38	35
males	3	2
females	35	33
queens	32	10
workers	3	23

In colony A, 94% of the total surviving female brood comprised queens, as compared with 30% in B. If it then be assumed that the six larvæ which died in colony A would have been workers, while the nine larvæ which died in colony B would have been queens and were preferentially destroyed by the workers, then 78% of a total female brood of 41 in A would have been queens as compared with a corresponding figure of 45% in B. Such a possibility of preferential destruction must be considered even though highly unlikely. Colony A, especially, had more than ample food and therefore no reason to destroy any larvæ. It would seem probable that the dead larvæ represent enfeebled or injured individuals, approximately equally divided between the two colonies, which would have been disposed of under any circumstances.

The difference between the figures 78% and 45% could conceivably be explained on the basis of chance assortment, but this is highly unlikely. If we assume on the basis of the blastogenic theory that of the original 88 larvæ 83 are female, and of the 83, 51 are predetermined as queens and 32 predetermined as workers, then the chances of obtaining 9 workers, 32 queens (colony A: 78%) plus 23 workers, 19 queens (colony B: 45%) are less than 1:100 the chances of obtaining an equal division of 16 workers, 25-26 queens in each colony. Unfortunately, I will be unable to undertake corroborative experiments which should be performed before these results may be considered conclusive.



Fig, 1. Number of larvæ pupated at a given time plotted against days after beginning of experiment. A, colony A; B, colony B. Solid lines, pupation curves of total brood; broken line, pupation curve of queens alone of colony B. It may be noted that in B, workers and males did not start pupating until the 13th day, or one day before all the queen larvæ had finished pupating.

The two colonies responded very differently in the rate of maturation of the larvæ. From figure 1, it will be noted that during the period when the entire brood of colony A is pupating, the queen larvæ alone, for the most part, are pupating in colony B. Even though the latter colony is getting much less food, the queen larvæ have matured at the same time as the larvæ in the well-fed colony, while the maturation time for the rest of the brood lags considerably behind that of the queen larvæ.

Conclusions.

It may be affirmed that, in all probability, with the ant *Leptothorax curvispinosus* only one type of female egg is laid, and that these eggs become queens or workers respectively according to the nature of at least one environmental factor acting upon them after being laid. The present experiment goes even farther than this, for in it the determination of queens and workers was effected at a comparatively advanced stage in larval growth, indicating that final determination may be considerably postponed. Exactly what environmental factors are involved is not evident. Quantity of food is one factor, from the nature of the experiment; but that is not all, for attempts to produce queens from *L. curvispinosus* larvæ during the summer by overfeeding met with no success. Larvæ on emergence from hibernation, therefore, differ from larvæ during the rest of the year in being, somehow, peculiarly susceptible to a "gynegenic" influence of quantity of food. This influence may be direct or may be transmitted to the larvæ secondarily through the workers. Perhaps it is the action of factors arising from various seasonal changes which produces this different responsiveness on the part of overwintered larvæ.

Now we can trace a possible pattern of events. As Winter approaches, there remains in the nest a variable number of larvæ of varying size whose growth has been brought to a standstill by the decline in food and increase in cold weather, possibly other factors. These larvæ emerge in the Spring somewhat reduced in size, but with their physiology so altered that under the influence of an abundant available food supply they can start development toward the queen form. All the larvæ are not the same in their susceptibility, however, so that when the food supply is small, only the most susceptible are affected; and there may be some, perhaps small or feeble larvæ, which are not affected at all. The larger the food supply, the more less susceptible larvæ are affected. This period of susceptibility lasts only a short time (indicated by the fact that the pupation curve of the queens in colony B is quite short and is simultaneous with the curve for A), after which the larvæ become resistant to the gynegenic action of food and become workers no matter how much food is offered them. While the queen larvæ are developing, the largest proportion of the available food goes to them, the rest of the larvæ taking comparatively little (indicated by the separation of queen and worker pupating curves of colony B). Thus the queen larvæ are enabled to grow to normal size at normal rate even though the colony is on reduced rations. A similar pattern, in reverse, could hold for those species in which the queens are produced in late Summer or Fall.

Summary

An experiment is described which indicates that the female castes of *Leptothorax curvispinosus* are determined trophogenetically and not blastogenetically.

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THE HISTOLOGY OF THE WING PADS OF THE EARLY INSTARS OF *PTERONARCYS PROTEUS* NEWPORT (PLECOPTERA)

By R. P. Holdsworth, Jr.

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Several very thorough papers have been published on the wing development of holometabolous insects. The differentiation of the wing, however, is so rapid that investigators are by no means unanimous as to the mode of formation of the blood lacunæ about which the adult wing veins subsequently form. Marshall (1913), studying *Platyphlax designatus* Walker, a trichopteran, stated that lacunæ develop in the wing Anlage of the last nymphal stage and that tracheæ do not enter until the wing has everted. Hundermark (1935) investigated *Tenebrio molitor* and reported that tracheæ grew into the newly everted wing disc and that later lacunæ formed about them. Kuntze (1935) in his exhaustive studies of *Philosamia cynthia* Drury (Lep.) claimed that lacuna formation preceded the entrance of the tracheæ and that lacunæ developed inward from the margin. Waddington (1939) speaks of the formation of vein lacunæ in Drosophila wings as being the fusion of small local lacunæ along the site of the presumptive adult vein. He does not refer to the method of formation of the small lacunæ nor are wing tracheæ mentioned in his paper.

From these studies and other investigations on holometabolous insects, it is not possible to determine the ancestral mode of lacuna formation. To elucidate the problems of lacuna formation and differentiation of wing epithelium one would logically turn first to the Heterometabola, but no histological investigation of any scope has been undertaken. Tower (1902) sectioned a first stage nymph of *Anasa tristis* De Geer (Hem.) and saw disc-like hypodermal thickenings in the dorso-pleural region on the wing bearing segments. At the time of the first moult the discs evert to form wing pads. Formation of a disc and its subsequent eversion also occurs in holometabolous forms. Regarding *Microcentrum latifolium* (Orthoptera), Tower reported that the first instar has well developed wing pads, which everted in the embryo but do not become external until the first nymphal moult. He does not note first occurrence of lacunæ.

Sulc (1911) sectioned the early instars of *Philaneus lineatus* (Hom.) in order to reconstruct the tracheal system. He found that in the first instar tracheæ do not extend to the site of the wing pad, which is later invaded by two tracheæ in the second instar. He found four longitudinal tracheæ in the wing pad of the third instar, a pattern which is elaborated in the fourth and fifth stages. Curiously enough, he did not describe or figure lacunæ, although they have been illustrated in non-histological works on wings of Homoptera.

Beck (1920) discussed the development of the wing vein in *Phyllodromia* (*Blatta*) *germanica;* this was not histological, but was concerned with the development of the wing's tracheal system throughout the life of the roach. Neither the advent nor the differentiation of lacunæ is mentioned.

In order to investigate the differentiation and growth of wing epithelia and to ascertain the relationship between the development of lacuna and trachea, *Pteronarcys proteus* Newport was chosen. This insect is a primitive plecopteran with at least fourteen nymphal stages. The writer was fortunate in obtaining several early instars which were studied exclusively by serial sections, since whole mounts of entire individuals or of wing pads do not show lacunæ. Specimens were fixed in Kahle's fluid (two hours), sectioned in paraffin at 6μ without difficulty or loss of sections and stained with Mallory's triple connective tissue stain.

The length of the specimens is not given as it is an unreliable index of a particular instar. Body length varies among fixed specimens: some are caused to telescope by the action of the fixative, others are relaxed at full length. Head width, however, enables one more definitely to determine the stadium to which a specimen belongs.

First Instar

Head width, .408 mm. A single specimen was obtained and sectioned. The wing anlage is not a disc of cells developed in the embryo and everted upon eclosion. The only external indication of wing buds in the first instar is a small flange where the pleurum and the tergum join. This flange can well be regarded as a lateral expansion of the tergum. Hypodermal cells on the tergal portion of the thoracic expansion grade from pavement epithelium to tall columnar cells, as one proceeds laterally. Lacunæ are not yet developed, nor are tracheæ associated with the anlage.

Second Instar

Head width .54 mm. Two specimens of this stage were studied: one, in the inter-moult phase; the other, just prior to its moult to the third instar. In the inter-moult specimen both meso- and metathoracic analgen have attained the same degree of development. A well marked sinusoid runs along the outer margin of each wing expansion, and is incomplete in that it does not communicate with the hæmocœle either anteriorly or posteriorly. In the left rear wing the sinusoid is 9μ in length and is occluded in one place by hypodermal cells suspended in it. In the other metathoracic expansion the sinusoid is evidenced by 20μ and 30μ lengths, separated by an occlusion.

Histological examination shows the sinusoid to be the result of attenuated cell ends not going directly to the basement membrane of the hypodermis. Instead the processes merge with the ends of neighboring cells to leave a space. Precisely the same sort of sinusoid is found in the prothoracic expansion. It follows, therefore, that the sinusoid is not the costal lacuna. It may be termed the precostal sinusoid, for it occurs peripherad of costa in all nymphal stages. It is a false lacuna situated at the base of large bristles and may be the site of trichogen cells. In nymphs about to moult the precostal sinusoid is obliterated by large trichogen cells.

Prior to the second moult the costal lacuna is developed. It is a space between the basement membrane of the wing epithelia and is readily distinguishable from the precostal sinusoid which is an intercellular space. In the late second instar costa is a marginal lacuna which communicates anteriorly and posteriorly with the hæmocœle. Although a few blood cells are present in the posterior portion of the lacuna it is not certain that blood can circulate because the anterior opening is very small. The costal lacunæ of the right fore, right hind, left fore and left hind wing pads measure 168μ, 162μ, 160μ and 140μ respectively.

With the exception of the right hind wing, the single trachea to the wing disappears in the dorsal epithelium of the bud, and does not approach costa or form a lacuna. In the right metathoracic flange, however, the trachea is worthy of note for its exceptional behavior. The trachea travels into the costa of this wing, the only instance where it does so in twenty-eight wing pads of early instars studied by serial section. 60μ from the site of apposition of the trachea to the dorsal wing epithelium, and 18μ past the anterior end of costa, the trachea enters the lacuna. In the next 42μ, the trachea moves across the lacuna into the ventral epithelium where it may be followed for 22μ to its end. As the trachea enters costa 18μ away from the lacunal opening it is obvious that the lacuna is not caused by a boring in of the trachea, nor does the diameter of the lacuna taper to conform to the tapering trachea.

In each segment of the pterothorax a nerve leaves the interganglionic connective at a point immediately anterior to the ganglion. The nerve associates itself with the wing trachea and enters with it into the dorsal wing epithelium. The nerve could not be traced further.

Because tracheæ are often considered to be inductors of lacunæ, it is well to digress upon the anatomy of the tracheal system. In the second instar a trachea extends to the wing for the first time. (It is the more anterior of the two branches which supply the wing of older nymphs. The posterior branch does not appear during the late third instar.) A large longitudinal trachea runs laterad of the alimentary tract, and in the wing bearing segments the longitudinal trachea receives perpendicularly an equally large branch from the anterior gill. From the junction of these large tracheæ to the corresponding junction in the succeeding segment runs a smaller trachea which arches out peripherally from the main longitudinal trachea. From the peripheral arch branches extend to the wing, leg, and posterior gill. In the late third instar a trachea extends for the first time to the posterior portion of the wing flange. This is the state of pterothoracic main tracheæ during the second, third, and fourth instars.

Third Instar

Head width, .68 mm. Killed early in period of cell division and growth preceding fourth instar. The old endocuticula is partly resorbed and the new integument is partly secreted.

The apposition of nerve and trachea is the same as that of the preceding instar. Costa communicates anteriorly and posteriorly with the hæmocœle and does not contain a trachea. Subcosta appears for the first time in the life history of *Pteronarcys proteus* during the period of hypodermal cell division in the last phase of the third stadium. Subcosta is open at the anterior end and opens posteriorly into costa at a point near to where the latter empties posteriorly.

In the right forewing 48μ posterior to the entry of the trachea onto the wing epithelium, one observes the opening of subcosta, and 30μ posterior to that opening is the point of entry of the trachea into the lacuna. The trachea is therefore associated with the wing epithelium for 78μ without having created an intercellular space, much less a lacuna. Once within the subcosta, the trachea travels for 48μ and moves from the dorsal to the ventral epithelium. The trachea ends outside of the lacuna 6μ before subcosta ends. With minor variations the behavior of the trachea in each of the three subcostas is the same. A small cross vein has already developed 60μ anterior to the distal end of subcosta.

Because the entry of the trachea into subcosta is so far removed from the anterior opening of the lacuna, subcosta could not possibly have been induced by the mechanical boring in of the trachea. Subcosta is not centered with respect to the trachea once it does enter. The lacuna does not taper, whereas the trachea tapers to nothing. Evidently the trachea does not induce the lacuna.

Head width, .79 mm. Killed late in period of cell division and growth prior to the moult to the fourth instar. Examination of the integument showed the old integument to be almost completely resorbed and the integument of the fourth instar in great part to be laid down.

The structure of the wing in this specimen differs from the early growth phase third instar. At the anterior margin of the wing a large trachea becomes applied to the dorsal wing epithelium. 24μ posterior to the point of application a lacuna appears but is not associated with the trachea. The lacuna is divided into three smaller lacunæ by cell processes forming partions. As the wing flange broadens posteriorly, the three lacunæ become separated in space by added cell processes which form a typical middle membrane. 48μ posterior to the first appearance of the lacuna, the trachea becomes associated with the most mesal lacuna. Posterior to this point the innermost lacuna bifurcates. 120μ from the opening of costa and 120μ from the posterior margin of the wing pad, the trachea goes deeply into the ventral epithelium and tapers to an end.

If one numbers the lacunæ inward from the margin, number three appears to be the new structure, and is therefore probably radius. The subcosta in the early growth phase third instar runs midway between costa and the hæmocœle, and sends a short branch to the anterior margin of the wing near its apex. The second lacuna in the late growth phase third instar has the same position and structure as it did in the early growth phase, whereas the new (third) lacuna runs next to the hæmocœle and forks at mid-length of the wing. The left metathoracic wing has the same anatomy with minor differences. The two remaining wings were compressed locally when they were sectioned so that one cannot follow the trachea. The three lacunæ, however, are readily identified. Four additional lacunæ, each about 50μ in length, make their initial appearance at the apex of the wing pad. Further study is necessary to determine their identity.

Fourth Instar

Head width, .88 mm. Four specimens were sectioned serially and examined. The anatomy of the wing pad is the same as that of the late growth phase third instar.

General Consideration and Conclusions: Before one is able to characterize vein lacunæ, one has to study blood lacunæ in the prothorax. When the costa is formed in the second instar, a blood lacuna develops in the prothoracic flange and like the costa runs in an arc to communicate anteriorly and posteriorly with the hæmocœle. Similarly, at the time of differentiation of subcosta, the prothoracic flange adds another lacuna which is entad of and parallels the first. (Later instars show that several more lacunæ are added.) Prothoracic flange epithelia do not oppose their basement membranes to form a middle membrane. Prothoracic lacunæ therefore differ histologically from vein lacunæ in having a diameter from 2½ to 4 times as great, and are not middle membrane structures.

From a study of the early instars of *Pteronarcys proteus* one concludes that: (1) the sole histological distinction of vein lacunæ is their middle membrane structure. One cannot say that vein lacunæ are also distinguished by tracheæ because costa rarely contains one, and costa in the early instars does not differ from subcosta or radius. (Costa, always an ambient structure, did contain a trachea in one of about 60 examined specimens of all ages. The other longitudinal lacunæ of older instars invariably contain both tracheæ and nerves. Costa never contains a nerve.)

(2) Lacunæ are not induced by tracheæ.

The writer is particularly grateful to Dr. Albert Miller of the University of Arkansas who supplied specimens of the first and second instars, and to Dr. F. M. Carpenter and Dr. A. B. Dawson who read and criticized this paper.

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DESCRIPTION OF PLATE VI.

Transverse Sections of *Pteronarcys proteus* Newport.

I. Metathoracic flange, x294, first instar, right side. The site of the wing disc is marked by the transition of pavement epithelium to tall columnar cells.

II. Mesothoracic wing pad, x294, second instar, left side. Precostal sinusoid and a middle membrane present. No lacuna or trachea developed.

III. Prothoracic flange, x294, second instar, left side. False lacuna present but a middle membrane not developed.

IV. Mesothoracic wing pad, x294, late growth phase second instar, left side. Costal lacuna is present.

V. Prothoracic flange, x294, same specimen as no. IV, left side. Blood sinusoid present.

VI. Prothoracic flange, x294, early growth phase third instar, right side. Two blood sinusoids are present. Middle membrane is not developed.

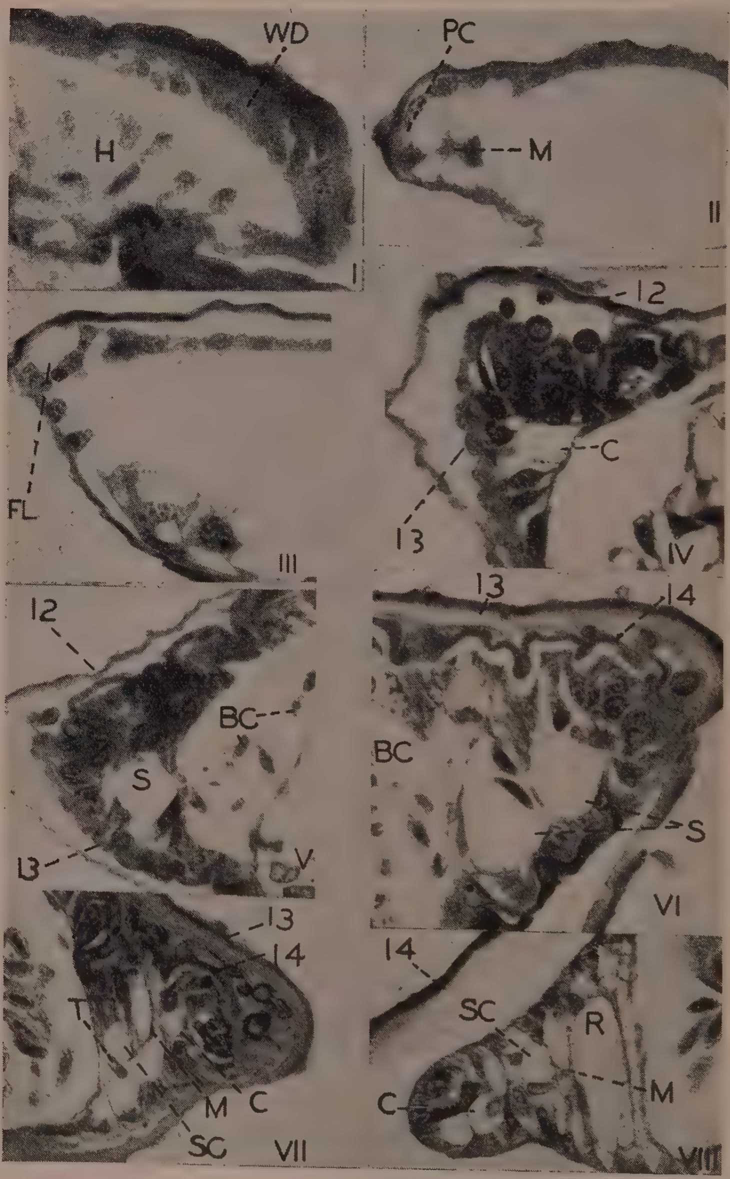
VII. Mesothoracic wing pad, x206, same specimen as no. VI, right side. Subcosta has formed.

VIII. Mesothoracic wing pad, x290, fourth instar, left side. Three lacunæ are visible.

Key to Abbreviations

BC	Blood cells
C	Costa
FL	False lacuna
I2, I3, I4	Integument second instar, etc.
M	Middle membrane
P	Precostal sinusoid
SC	Subcosta
R	Radius
T	Trachea
WD	Wing disc

PSYCHE, 1940 VOL. 47, PLATE VI.



HOLDSWORTH — WING PADS OF PTERONARCYS

A SYNOPSIS OF THE GENUS ACERATASPIS (HYMENOPTERA, ICHNEUMONIDÆ)

By Charles D. Michener

University of California, Berkeley

The genus *Aceratapsis* was originally described from Japan. A second species has been found in Formosa, and in this paper a third is described from southern China. A redescription of the genus is here given, since the original characterization proves to be inadequate in the light of the species discovered since its publication.

Aceratapsis Uchida

Aceratapsis Uchida, 1934, Ins. Matsumurana, **9**: 23
Cushman, 1937, Arb. u. morph. u. tax. Ent. Berlin-Dahlem, **4**: 290

Cerataspis Uchida (nec Gray), 1934, Trans. Sapporo Nat. Hist. Soc., **13**: 275

Moderate sized, coarsely punctate, black, with yellow facial markings and abdominal fasciæ. *Head* not broader than thorax; face longer than broad, evenly convex below the antennæ, without a facial shield; epistomal suture absent; antennal sockets close together, separated by a strong longitudinal keel, the lower end of which is continuous with the elevated, convex, lower part of the face; mandibles bidentate at apices; hypostomal carinæ not very high; no palpal segments swollen as in *Metopius;* eyes seen from the side broadest below the middle (at least in *sinensis*). *Thorax* short and high; sides of pronotum shining and impunctate, with longitudinal grooves; mesoscutum without parapsidal furrows; mesoscutellum with a basal, median, impunctate, longitudinally carinate, transverse, depressed area, behind which is an elevated area, the sides of which are margined, and the posterior lateral angles of which are produced posteriorly, as in *Metopius*. Propodeum short, its spiracles short oval, its surface incompletely but strongly areolated. Wings with numerous, rather long hairs (at least in *sinensis*); areolet of fore wing large, briefly petiolate or costal margin short; recurrent vein with a single fenestra, which is near its costal end. Legs rather slender, claws strongly pectinate, middle tibiæ with two apical spurs. *Abdomen* not petiolate, apical segments swollen and turned downward; spiracles of first segment round, slightly anterior to the middle of the segment, the dorsal profile of which is strongly angulate about the middle; first three or four abdominal terga with two or three conspicuous, longitudinal, middorsal, parallel or nearly parallel carinæ; segments two, three, and four broader than long; sixth tergite very large, bulbous, forming the rounded apex of the abdomen; ovipositor slightly exerted.

Genotype: *Cerataspis clavata* Uchida, by original designation.

Key to the species of Acerataspis

1. First three abdominal tergites with *two*, parallel, longitudinal, dorsal carinæ. .... *sinensis*
   First three tergites, and sometimes the base of the fourth as well, with *three* parallel, longitudinal, dorsal carinæ. 2
2. Fourth abdominal tergite with longitudinal, dorsal carinæ on basal half; first tergite with apical angles yellow, and tergites two, three, and five in large part yellow. .... *formosana*
   Fourth abdominal tergite without longitudinal carinæ; fourth abdominal tergite in large part yellow, fifth yellow on posterior margin, others black. .... *clavata*

Acerataspis clavata (Uchida)

Cerataspis clavata Uchida, 1934, Trans. Sapporo Nat. Hist. Soc., **13**: 276

Acerataspis clavata Uchida, 1934, Ins. Matsumurana, **9**: 23

Type from Hikosan, Kiushu, Japan, in the Entomological Institute of the Hokkaido Imperial University. The species is also known from Tosa, Shikoku, Japan.

Acerataspis formosana Cushman

Acerataspis formosana Cushman, 1937, Arb. u. morph. u. tax. Ent. Berlin-Dahlem, **4**: 291

Type from Suisharyo, Formosa, in the Deutsches Entomologisches Institut.

Aceratsaspis sinensis Michener, n.sp.

Female: Length 9 mm. (with the apex of the abdomen turned down). *Head* rather small, black, pubescence dull white, upper three-fourths of area between anterior margin of clypeus and antennal sockets yellow, lower margin of this yellow area arcuate concave, inner ocular orbits narrowly brown, more broadly black toward upper part of yellow area, so that yellow does not reach ocular margins; keel between antennal sockets yellow. Face below antennal sockets coarsely and confluently punctured; rest of head with smaller punctures, for the most part separated by less than their diameters; ocelli large, distance between posterior pair greater than an ocellar diameter, slightly less than distance to eye margin; genæ convex, about one-half as wide as eye. Antennæ dark brown, lighter beneath than above; mandibles dark brown medially; palpi dark brown. *Thorax* black, pubescence dull white, a minute dull yellow spot below each tegula, inner margins of scutellar processes brown, tegulæ dark brown. Thorax largely coarsely and closely punctate, lower lateral portions of pronotum impunctate, with about six longitudinal ridges; sternauli with punctures sparser than elsewhere on mesepisterna; posterior margins of mesepisterna and entire metapleura shining and nearly impunctate, the latter sclerite with a few small, scattered punctures above; basal depression of scutellum with three longitudinal carinæ; posterior processes of scutellum connected by a carina, the short median section of which is along the posterior margin of the scutellum; metanotum with a small, elevated, median area, margined on each side by an angulate carina; propodeum with a rather small basal median area, posterior to which is a broad area (see figure), completely separated from lateral apical areas. Fore legs dark brown, apices and anterior surfaces of femora yellow, and bases and anterior surfaces of tibiæ yellow; middle legs dark brown; hind legs black. Wings grayish as a result of numerous long hairs inserted on the nearly hyaline membrane; wing veins and stigma very dark brown; areolet not petiolate, but costally directed side very short. *Abdomen* with sterna yellow; terga one to three black, four orange yellow, the base black, the apical margin dark brown, five black with a subapical transverse, orange yellow band, six black. Pubescence of tergites one to four dull white, of following tergites black. Punctures of first three abdominal tergites coarse and approximate, of following tergites finer and more widely separated; third tergite nearly twice as broad as long, fourth slightly more than twice as broad as long; first three abdominal tergites with a pair of longitudinal, dorsal carinæ, parallel on first two tergites, slightly converging posteriorly on the third.

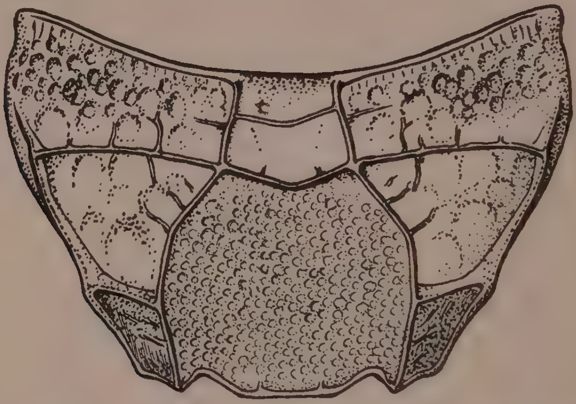


Fig. 1. Posterior dorsal view of propodeum of *Acerataspis sinensis* Michener.

Holotype female: Yim Na San, east Kwantung, south China, June 14, 1936 collected by Mr. J. Linsley Gressitt, on loan deposit to the California Academy of Sciences.

This species is easily distinguished from both of the previously described species of the genus by the presence of two instead of three longitudinal carinæ on the first three abdominal tergites. It differs further from *A. formosana* by the acarinate fourth tergite, the entirely black first three abdominal tergites, the largely yellow fourth, and the primarily black fifth tergite, and the black scutellum. It differs from *A. clavata,* in addition to the first character given, by the markedly different areolation of the propodeum and the nonpetiolate areolet. The color pattern is remarkably similar to that of *clavata.* The basal median portion of the propodeum is asymetrical in the holotype, as shown in the figure.

THE MATING HABITS OF THE WINTER MECOPTERON, *BOREUS BRUMALIS* FITCH.

By G. C. Crampton, Ph.D.

Massachusetts State College, Amherst, Mass.

The family Boreidæ contains the small winter scorpionflies which differ from the bulk of their allies in that they are active during the winter, running about on the snow when most adult insects are dormant from the cold.

The life histories of the American species of *Boreus* have not been worked out in detail, but since their larvæ may be found in the moss about the roots of trees in cemeteries, or along the sides of wooded roads, at almost any time of the year, it is extremely probable that there is more than one generation a year. Pupæ found in the same situations, in the neighborhood of Amherst, emerged in late October; and it is probable that adults are to be found at that time, although they were not taken in the open until later in the year. The pupæ are not immobile, but wriggle about actively when they are removed from their pupal cavities in the earth about the moss roots.

Adult specimens of *Boreus* found on the snow in December and February[1] when brought indoors and placed in jars containing moss, in the hopes that they might oviposit in the moss, were too greatly excited by their unusual surroundings to oviposit, and spent most of the time climbing to the tips of the moss stems and jumping off like fleas toward the light of the windows in which the jars were placed. This leaping toward the source of light was not observed in any other Mecoptera; and the leaping habit exhibited by *Boreus* lends some weight to Tillyard's suggestion that *Boreus* is related to the ancestors of the fleas.

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[1] The writer is deeply indebted to Dr. Inez Williams, formerly a student of the Massachusetts State College, for her assistance in collecting much of the material upon which these observations were made, during the winter of 1933.

As the females walked about over the moss in the jars, the males mated with them readily. As described by Withycomb, 1926, (Entomological Monthly Magazine, vol. 62, pp. 81-83) for the English species of *Boreus*, when mating takes place, a male runs up beside a female, and hooking his slender curved wings over her back, extends the end of his abdomen beneath her, and endeavors to lift her off her feet. If she does not struggle too strenuously, he usually succeeds in lifting her across his back, and grasping the parts with his genital forceps, he forces down the projecting valves of the eighth sternite of the female and inserts the intromittent organ into the genital aperture thus exposed.

As the female becomes quiescent, the male shifts her body along his back to the position shown in Figure 1, in which it may be seen that the male now holds the female by grasping her fore legs near the bases of her front femora by means of his wings; and her beak extends downward between his wings in the manner shown in the figure. The female is held in position at the terminal end by means of the male's genital forceps, or forcipate parameres, which grasp the terminalia of the female near the bases of the valves of her eighth sternite, the tip of the male's abdomen being turned up over his back in order to hold the intromittent organ within the aperture of the female above him, as is shown in the accompanying plate. In this position, the valves of the female's eighth sternite project ventro-caudad below the tip of the male's upturned abdomen, while the terminal segments of the female project posteriorly over the upturned hypandrium. or ninth sternite of the male, as is shown in the figure.[1]

The male carries the female about on his back in this manner for some time; and the muscles operating the genital forceps become so set during the process that a copulating pair may be lifted up on a piece of paper without becoming separated; and in several instances the writer succeeded in dumping them into hot fixing fluid without their becoming separated—as was the case with the pair from which the accompanying figure was made.

Egg laying probably occurs shortly after mating, although the writer did not succeed in observing the process. According to Withycomb, the eggs are deposited in moss.

[1] The writer is deeply indebted to Mr. Hagar, a former student of the Massachusetts State College, for making the accompanying figures.

The subgenital valves of the female are unique among the Mecoptera, and are borne on the eighth sternite like those of female Tipulidæ, although the female Diptera have sternal structures of the ninth sternite not present in the females of *Boreus*. It is possible that the valves of the eighth sternite of *Boreus* may represent the ventral valves of the ovipositor of female Orthoptera, but the exact homologies of these parts in female Diptera, *Boreus*, etc., have not been definitely determined.

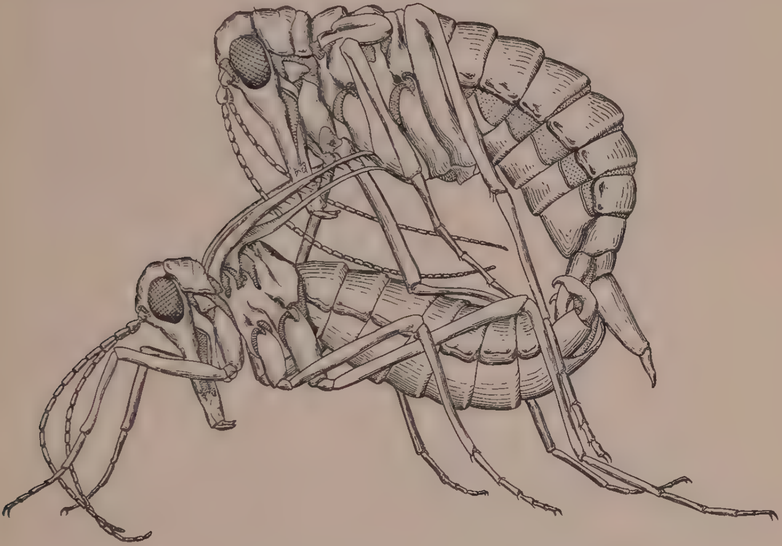

Fig. 1. Mating Position of *Boreus brumalis*.

Since female Tipulidæ use the slender flanged rigid cerci, which are shaped exactly like those of *Boreus*, to form the dorso-terminal portions of the egg-laying apparatus, it is probable that a female *Boreus* uses her terminalia in a similar manner to deposit her eggs in moss.

The terminal segments of the genital forceps of the male of *Boreus*, etc., represent the parameres of male Hymenoptera, etc., while the basal sclerites represent the parameral plates, as was pointed out by the writer in several publications. Recent morphologists, however, do not accept this interpretation, and homologize the segments of the forcipate genitalia of male Mecoptera, Diptera, Trichoptera, etc., with the coxites and styli of such primitive insects as *Machilis,* etc., despite the fact that the forcilate genitalia of male Hymenoptera (and Coleoptera) are clearly homologous with the forcipate genitalia of male Mecoptera, Diptera, Trichoptera, etc., and if the forcipate genitalia of male Hymenoptera and Coleoptera represent parameres, then the forcipate genitalia of all Holometabola represent parameres throughout the series of closely related insects.

There are marked sexual differences in the shape and structure of the vestigial wings of the two sexes of *Boreus.* As is shown in the accompanying figure, the wings of the male are slender curved tapering structures, and the front wings of the male are lined along both the anterior and posterior borders by a row of stout bristles to aid in holding the female in copula. The wings of the female, on the other hand, are flat lobe-like structures, having no apparent functional significance.

NEW CHRYSOPIDÆ FROM AUSTRALIA

By Nathan Banks

In Psyche vol. XVII, pp. 99 to 104, 1910, I described twelve new species of Australian Chrysopidæ, nine belonging to the genus Chrysopa as it has been used (though wrongly) for many years. I now add five new species, and give a new synoptic table for them.

Of those I have not seen are two that I consider distinct, *extranea* E. Petersen which I can place in the key from his figure of the wings, and *personata* Navas which, according to his figure, has quite different facial marks from any seen by me.

Three of the Navasian species, *deutera, reaumeri,* and *notosticta* have been placed by E. Petersen as synonyms of *Ch. ramburi,* and I believe correctly.

Ch. assimilata does not appear, from description, to differ from *Ch. innotata.*

The species described by Tillyard from Norfolk Island cannot be placed from his figures and descriptions until one has fresh material from that island; *C. leai* goes in the section of *edwardsi* and *extranea,* possibly also *C. arancariæ.* It would not be unusual if some of them occur in Australia, but I cannot fit any of the five new species described below to any of them. *Ch. olatatis* Bks. is possibly a male of *Ch. latotalis,* but of the many males of *latotalis* I have seen none that have the pale, slightly yellowish stripe from back of head along middle of thorax; the outward appearance of the genitalia is the same, but in *olatatis* (seen from behind) there is a plate above the edge of the last ventral segment with a straight upper margin, I do not see this in *latotalis; olatatis* is from Port Darwin, all the *latotalis* I have seen are from middle and north Queensland. *Ch. latotalis* is very similar to *Ch. basalis,* but without the dark mark on basal antennal joint; the external genitalia and the stigma appear the same.

SYNOPSIS OF SPECIES

1. More than seven cubital cross-veins beyond end of the divisory veinlet; palpi and pronotum marked with black. .... 2.

   Normally but six or seven cubital cross-veins beyond the end of the divisory veinlet. .... 3.

2. Divisory cell twice as long as broad; a dark spot at inner base of basal joint of antennæ. .... *edwardsi*

   Divisory cell about as broad as long; no such spot; a dark line between antennæ. .... *extranea*

3. Hind tibia but little more than three times as long as the tarsus, not swollen; usually two dark marks below antennæ, a dark line across pronotum, and two short marks each side, basal joint of antennæ usually with an upper and an outer dark mark and two lines on vertex. .... *ramburi.*

   Hind tibia more or less plainly swollen, and four times as long as tarsus, or longer, rarely the above marks on face and pronotum. .... 4.

4. Basal antennal joint with dark mark on outer or inner side; antennæ always pale. 5

   No dark marks on basal joint of antennæ, unless the antennæ are black, beyond second joint .... 7.

5. Gradates bordered with dark or yellowish. .... 6.

   Gradates not bordered; a black mark between the antennæ at base; dark stripe on basal joint on both outer and inner sides. .... *signata.*

6. Veins bordered with yellowish; radial sector very sinuous; basal antennal joint with but one dark line; gradates pale. .... *irregularis.*

   Gradates dark and bordered with dark, also some other veins; basal joint of antennæ with two dark lines. .... *regularis.*

7. The divisory veinlet ends plainly before the cross-vein above; veins nearly all greenish; head, antennæ, and palpi pale, unmarked; gradates mostly remote from each other. .... *otalatis.*

   The divisory veinlet ends at or beyond the cross-vein above, at least normally. .... 8.

8. A dark spot at base of the stigma; gradates bordered, pronotum and mesonotum with a dark spot each side. .... *jocaste.*

   No distinct dark spot at base of the stigma. .... 9.

9. A distinct dark spot on radial sector more than half way to tip, and extending back on two veins; gradates faintly bordered; a dark spot under each eye; palpi marked with dark; a faint reddish stripe each side on pronotum. .... *signatipennis*

   Not as above .... 10.

10. Many cross-veins as well as gradates bordered with dark; antennæ pale, a reddish mark under each eye. .... *traviata.*

    Cross-veins not plainly bordered. .... 11.

11. Antennæ plainly dark beyond the second or third joints; head usually with red on vertex or face. 12

    Antennæ not plainly dark; head without red marks on vertex. .... 14.

12. Stigmal area between costa and subcosta practically without cross-veins, or only one near tip. .... 13.

Stigmal area between costa and subcosta with several cross-veins and others broken in middle; base of divisory cell not thickened and but little oblique; the branches of radial sector but little bent at inner gradates; a large red spot just above base of each antennæ; antennæ dark from second joint out; seven cubital cross-veins beyond divisory. .... *darwini.*

13. The branches of radial sector at the inner gradates are scarcely bent; pronotum long; the antennæ are dark from beyond third joint; the base of divisory cell very oblique and very plainly thickened. .... *atalotis.*

The branches of radial sector at the inner gradates are strongly bent, so the continuation of each branch appears to come from the middle of the end of preceding cell; antennæ black beyond second joint; pronotum not so long; hairs on veins longer; base of divisory cell only slightly oblique and not thickened. .... *satilota.*

14. Cubitus dark; veinlets behind base of radial sector partly dark; outer gradates dark; seven cubital cross-veins beyond divisory cell; dark spots above base of wings. .... *alcines.*

Cubitus not darkened, gradates and various other cross-veins plainly dark; often a dot under each eye. .... *innotata.*

Neither cubitus nor gradates plainly dark .... 15.

15. Costal stigmal area with a few cross-veins and beyond are four cross-veins before end of subcosta (not clearly marked). .... *ramburi.*

Costal stigmal area tapering to tip and without cross-veins, except possibly one near tip. .... 16.

16. Base of divisory cell very oblique and thickened; pronotum as long or longer than broad; face not marked with reddish. .... *italotis.*

Base of divisory cell scarcely oblique and not thickened; divisory veinlet often ending at cross-vein above or just beyond; pronotum broader than long; in female sometimes two reddish spots above clypeus; in male the stigma is solid yellowish, much like *basalis.* .... *latotalis.*

Chrysopa edwardsi, sp. nov.

Face pale, a dark streak under each eye, and the lateral margins of clypeus dark; palpi pale, slightly marked with dark; antennæ pale, basal joint with an oblong brown spot on the upper inner side near base; pronotum green, with a median yellowish stripe, each side is a sinuous dark line, part way from middle to side, sometimes it is broken into two or three spots; near the posterior corner of pronotum is a dark brown spot; on each side of the anterior lobe of mesonotum is a dark spot; sometimes a dark line on each lateral lobe of the mesonotum; abdomen brownish, with a more or less plain dark streak each side. The fore wing has one or two dark dots at extreme base; nearly all cross-veins partly dark, usually at ends; the gradates, anals, and sometimes other veins near base wholly dark.

In hind wings the costals and many radial cross-veins dark, stigma not very distinct. The wings are fairly broad, almost acute at tips; the hairs on veins quite long; the gradates are in parallel series, the outer about seven, the inner usually ten, extending much basally; there are eight or nine cubital cross-veins beyond the divisory cell, the latter ends much beyond the cross-vein above, the cell being fully twice as long as broad; the post-cubital area is much wider than the costal, the second cubital cell scarcely longer than the third. In the costal stigmal area there are no cross-veins, but beyond are two or three, the branches of radial sector scarcely bent at inner gradates. In the hind wings the inner gradate series also extends basally; the triangular cell is quite long, and basal part of medius bends down in a gradual curve.

The pronotum is about as broad behind as long in middle, the sides sloping forward; the hind tibia not swollen.

Length of fore wing 16.5 mm., width 6 mm.

Two from "Australia, Edwards" (in M.C.Z.) and two from "Victoria, Australia, Edwards coll.", probably H. Edwards, in the Amer. Mus. Nat. Hist. Type M.C.Z. no. 25452.

Chrysopa edwardsi puncticollis n. var.

In general similar to the typical form, but the palpi are more heavily dark; on the pronotum besides the sinuous line each side, and the spot near posterior angle, there are three other spots on each side: one toward the front, one below it on the lower margin, and one behind the latter, visible only from below; the spot on basal joint of antennæ is rather reddish, and there are two short parallel reddish lines on middle of vertex.

Size as the type.

One from Tasmania. Type M.C.Z. no. 25453.

Chrysopa traviata sp. nov.

Pale yellowish green; a reddish spot under each eye, and usually a red line inward of it; last joint of palpi partly black; antennæ pale, unmarked, not very long. In fore wings the gradates are dark, and many cross-veins at ends;

the gradates, veins along hind margin, and most of the cross-veins, except costals and radials, bordered with pale brown; in hind wing the costals mostly dark. The wings are rather slender, almost acute at tip; the hairs on veins moderately long. In fore wing the gradates are in parallel series, but the inner further from outer than from the radial sector, about five gradates in each series, the branches of radial sector but little bent at inner gradates; six cubital cross-veins beyond the divisory cell, latter small, over twice as long as broad, ending at or beyond the cross-vein above, its base faintly thickened; second cubital cell but little if any shorter than the third; costal area no broader than post-cubital area, the latter but little broader than the cubital area; the costal stigmal area without cross-veins, but two or three beyond.

In hind wings the gradates, about four in each row, rather far apart; the triangular cell small, the union of radial sector and medius long, the basal part of medius quite suddenly bent down. Pronotum broader than long, sides nearly parallel, narrowed near front; hind tibia plainly swollen.

Length of fore wing 11 mm., width 4 mm.

Several specimens from Redlynch, North Queensland, 20 August to 14 October (Wind. coll.). Type M.C.Z. no. 25454.

Chrysopa jocaste sp. nov.

Head and thorax nearly white, abdomen yellowish, a small brown spot under each eye, palpi pale, unmarked, antennæ pale, becoming darker toward tip, pronotum with a large brown spot near each anterior corner, and a similar spot over base of fore wings. Wings with pale greenish venation, gradates and some other cross-veins more or less dark, the gradates and many other cross-veins and the marginal forks bordered or clouded with dark, the triangle below third cubital cell wholly clouded, a larger darker cloud over the radial sector just before stigma and extending back over the bases of two branches behind, these branches are nearer to each other at base than the others; at base of stigma is another brown spot over three brown cross-veins.

In hind wings the veins are pale, unclouded, but a dark dot at base of stigma. Wings moderately broad, acute at tips, hairs on veins rather short toward wing-base, plainly longer near tip.

In fore wing the gradates are parallel and nearer to each other than the outer row to the hind margin, about six in each row, those near base widely separated; six (or seven) cross-veins beyond the divisory, the latter ends at or just beyond the cross-vein above, the divisory cell twice as long as broad; branches of radial sector little bent at inner gradates; the costal space about as broad as the post-cubital, the latter much broader than the cubital area; costal stigma area without cross-veins, but one or two beyond.

In hind wing but two inner and five outer gradates, the triangular cell is slender and the free part of medius slopes down gradually.

Pronotum short, much broader than long, the sides slightly convex; hind tibia much swollen.

Length of fore wing 13.5 mm., width 5 mm.

One from Lankelly Creek, McIlwaith Range, Cape York, North Queensland, 8 June (Darlington). Type M.C.Z. no. 25455.

Chrysopa alcines sp. nov.

Body pale; the clypeus is plainly reddish; palpi and antennæ pale, unmarked, pronotum also; a dark spot above base of each wing; venation largely green, but in fore wings the cubitus from second cubital cell out is plainly brown; the outer gradates also brown, and the radials and some costals dark in middle; stigma indistinct.

The wings are moderately slender, tips rounded, the hairs on veins rather long; in fore wings the costal and post-cubital areas about equal in width, the post-cubital about a third broader than the cubital area; seven cross-veins beyond end of divisory cell, latter twice as long as broad, ending beyond the cross-vein above, second cubital plainly shorter than third; the gradates in nearly parallel series, about five or six in each row, inner row extending somewhat basally and is generally nearer to radial sector than to outer row; the branches of radial sector scarcely bent at inner gradates; costal stigmal area without cross-veins. In hind wing three inner gradates, one quite far basad, and five outer; the triangular cell is small, and the free base of medius curves strongly down.

Pronotum nearly as long as broad, sides parallel; hind tibia plainly swollen.

Length of fore wing 13.5 mm., width 4.5 mm.

From Middle Queensland (Perkins). Type M.C.Z. no. 25456.

Chrysopa darwini, sp. nov.

Body pale yellowish, tip of abdomen darker; palpi pale, unmarked, antennæ from second joint out dark, but fading before middle, above each antenna is a large deep red spot in the depression, the basal joint of antennæ also slightly reddish above; the pronotum shows faintly some reddish on each side-margin; veins and cross-veins green in both front and hind wings, stigma not conspicuous. The wings are moderately slender, not acute at tips, hairs on veins fairly long. In fore wings the gradates are parallel, the outer as near inner as to hind margin, the outer of seven, the inner of six veinlets, but the basal one is far before the others, the branches of radial sector only a little bent at inner gradates; seven cubital cross-veins beyond the divisory, the latter ending only a little beyond the cross-vein above, the cell more than twice as long as broad, the base of cell only a little oblique and not plainly thickened, the second cubital cell is much shorter than the third; the costal area hardly broader than the post-cubital area, latter only a little wider than the cubital area; the costal stigmal area has no cross-veins, but two or three beyond. In the hind wings the triangular cell is fairly long and the free base of medius curved gently; there are four inner and five outer gradates, about parallel and the outer row about as near inner row as to outer margin.

The pronotum is about as long in middle as broad behind, narrowed near front; the hind tibiæ are plainly swollen.

Length of fore wing 14 mm., width 5 mm.

One from Port Darwin (Dodd coll.). Type M.C.Z. no. 25457.

NEW SPECIES OF NORTH AMERICAN DIPLOTAXIS (COLEOPTERA; SCARABÆIDÆ)

By Mont A. Cazier

University of California, Berkeley

The new species presented in this paper were found among material submitted for determination by various friends. The writer would like to express his sincere thanks and appreciation to O. L. Cartwright and R. H. Baker for making available the Mexican material which is so closely allied to the Texas and Arizona fauna. Thanks are also due L. W. Saylor, W. F. Barr, R. G. Dahl, K. S. Hagen and J. C. von Bloeker for material loaned during the course of these studies.

The descriptions are arranged so that the diagnostic portion includes the main characters used by Fall [1] (1909) in his key. This will enable the reader to refer directly to the most closely allied species.

Diplotaxis arta Cazier, new species

Small, black; upper surface glabrous; labrum broadly, arcuately emarginate; mentum horizontal, slightly convex behind, strongly declivous at anterior third, the declivity margined by an acute arcuate raised line and a row of erect setæ; pronotal angles not impressed, sides not bisinuate; front of head without convexity; metasternum normally long, elytra not connate; ungual tooth short, nearly perpendicular to claw, median in position; clypeus rotundate, anterior margin subtruncate medially.

Head densely punctate, punctures coalescent or separated by about one-fourth their own widths, front on same plane as clypeus; clypeus punctate as in front, clypeal structure broadly interrupted medially, side margins shallowly sinuate medially, anterior margin subtruncate medially, angles evenly rounded, margins shallowly reflexed. *Pronotum* as wide as humeral angles of elytra, side margins evenly rounded, widest about middle; anterior margin nearly as wide as basal margin; disk with large punctures separated by about their own widths, more dense laterally, without lateral impressions. *Elytra* with sides subparallel to apical sixth, evenly rounded to apex, margins clothed with short erect pile; humeral and apical umbones prominent; surface irregularly punctate, punctures separated by about twice their own widths, costæ obscure, not elevated. *Undersurface* clothed with short golden pile; anterior tibiæ tridentate, basal tooth median in position, hind femora sparsely punctate throughout outer surface, hind coxæ sparsely punctate on apical half, posterior tarsi equal in length to hind tibiæ. Length 9 mm., width 4.5 mm.

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[1] Fall, H. C., 1909, Revision of the Species of Diplotaxis of the United States. Trans. American Entom. Soc. 35:1-97.

Holotype in the writer's collection, taken in Cedar Canyon, Providence Mountains, San Bernardino County, California, June 10, 1940 by W. F. Barr on *Franseria eriocentra* Gray. Five paratopotypes deposited in the collections of W. F. Barr and the author.

Diplotaxis arta Cazier is most closely allied to *Diplotaxis fimbriata* Fall but can be distinguished from that species by its narrower pronotum, subparallel elytra, prominent humeral umbones, by having the pronotum and elytra fimbriate with short golden hairs and by having the metasternum longer. The metathoracic wings in this species are more highly developed than those of *D. fimbriata*. From *D. pacata* Lec. it can be distinguished by its more parallel form, larger and more densely placed punctures throughout, by lacking the lateral pronotal impressions, by having the side pronotal margins evenly rounded rather than subangulate and by its indistinct elytral costæ. It can be distinguished from *D. brevidens* Lec. by its subtruncate anterior clypeal margin, evenly convex and wider front of the head, by its less angular side pronotal margins and by its less hairy posterior tibiæ.

Diplotaxis ungula Cazier, new species

Medium sized, reddish-yellow; upper surface glabrous; labrum broadly accurately emarginate; mentum subhorizontal and nearly flat posteriorly, declivous in front, declivity margined posteriorly by a more or less acute arcuate raised line and a row of erect setæ; pronotal angles not impressed, side margins not distinctly bisinuate; front of head without post clypeal convexity; metasternum normally long; ungual tooth antæ-median in position, shorter than superior portion of claw; anterior clypeal margin shallowly sinute medially; sides of pronotum strongly, subangularly rounded at middle, not sinuate before or behind; clypeal margin broadly reflexed.

Head densely punctate, punctures separated by about one-fourth their own widths or coalescent, sparsely clothed with short golden pile; clypeus densely punctate, punctures separated by about one-fourth their own widths or coalescent, surface sparsely clothed with short golden pile; clypeal suture widely interrupted medially, margins strongly reflexed, anterior more strongly than lateral, anterior margin subtruncate or shallowly emarginate medially, lateral margins convex medially shallowly produced posteriorly at juncture with canthi, canthi strongly angulate in front of eyes. *Pronotum* shallowly convex, side margins prominently subangular at middle, margins in front and behind nearly straight, anterior angles not prominent; anterior margin narrower than posterior margin; surface moderately punctate, punctures separated by about twice their own widths. *Elytra* widest at about apical third; humeral and apical umbones prominent; surface with costæ obscure but present, first intercostal space irregularly punctate, punctures separated by about twice their own widths, second intercostal space with single irregular row of punctures. *Undersurface* sparsely clothed with rather long golden pile; anterior tibiæ strongly tridentate, basal tooth slightly post-median in position, tarsi longer than tibiæ, tibiæ clothed with long golden pile on inner surface, tarsal claws long, cleft subapically, inner tooth truncate. Length 11 mm., width 5.4 mm.

Holotype for Eagle Pass, Texas, March 30, 1908 returned to L. W. Saylor of the United States Biological Survey for deposition in the United States National Museum. One paratopotype in the writer's collection.

This species appears to be closely allied to *Diplotaxis sulcatula* Fall and *D. beyeri* Schaeffer. It can be separated from *D. sulcatula* by its angulate side clypeal margins, by its more angulate side pronotal margins, by its more proximally placed basal tooth of front tibiæ, by the long pile on the tibiæ and by the longer tarsal claws. From *D. beyeri* it can be distinguished by its subtruncate anterior clypeal margin and convex rather than sinuate side clypeal margins, by its less densely punctate pronotum and by the long tibial pile. From *D. illustris* Fall it can be separated by its reddish-yellow color, by its more strongly reflexed clypeal margins, by its angulate canthi, more strongly rounded lateral pronotal margins, by its much wider anterior tibiæ, by the post-median position of the basal tooth of the anterior tibiæ, and by the less dense tibial pile.

Diplotaxis bakeri Cazier, new species

Medium sized, black; upper surface glabrous; labrum broadly, arcuately emarginate; mentum feebly oblique behind, strongly declivous in anterior two-fifths, declivity concave from side to side, posterior margin convex but without raised line or setæ; thoracic angles not impressed; hind femora impunctate between submarginal rows of setigerous punctures; tarsal claws post median in position.

Head with punctures separated by about their own widths above, more densely placed anteriorly, front only slightly raised along clypeal suture; clypeus densely punctate, punctures separated by about one-fourth their own widths, suture entire, margins shallowly reflexed, anterior margin shallowly sinuate medially, angles evenly rounded, side margins shallowly sinuate, canthi not angulate; antennæ ten-segmented. *Pronotum* convex, side margins subangulate medially, sides strongly constricted anteriorly, narrowly constricted basally, anterior angles sparsely produced; anterior margin narrower than basal margin; surface shining, sparsely minutely punctate, punctures separated by two to three times their own widths, more closely placed laterally, medially with faint indication of longitudinal impression. *Elytra* with shallow costæ evident, intercostal spaces irregularly punctate, punctures separated by about one to two times their own widths, surface minutely alutaceous, costæ with single median row of small punctures; humeral umbone prominent; sides widest at apical third, evenly rounded apically. *Undersurface* sparsely clothed with short golden pile; anterior tibiæ tridentate, basal tooth slightly ante-median, tarsal claws with inner, truncate tooth ante-median, hind tarsi shorter than hind tibiæ. Length 10 mm., width 5.5 mm.

Holotype in the writer's collection, taken at Rancho La Golondrina, Rio Sabinas, Muzquiz, Coahuila, Mexico, June 28, 1938 by Rollin H. Baker after whom the writer takes pleasure in naming this species. Forty-three paratopotypes deposited in the collections of O. L. Cartwright, R. H. Baker and the author.

This species appears to be most closely allied to the Texan *Diplotaxis belfragei* Fall but can be readily distinguished from it by having the mentum declivous from anterior two-fifths rather than the middle, by its smaller size, generally more strongly angulate side pronotal margins, by the smaller less dense pronotal punctures and by its longer truncate ungual tooth. The mentum is somewhat variable in the type series and might conceivably allow specimens to be keyed out to the bracket including *D. mœrens* Lec. and *D. punctipennis* Lec. in Fall's key. *Diplotaxis bakeri* can be separated from *D. mœrens* by its shallowly emarginate labrum, more sparsely and finely punctate pronotum and by its more strongly declivous mentum. From *D. punctipennis* it can be separated by its distinctly sinuate side clypeal margins, by the smaller and more sparsely placed pronotal punctures and by having the inner truncate tooth on the anterior tarsal claws distinctly shorter than the claw proper. *Diplotaxis bakeri* superficially resembles *D. maura* Fall but can be distinguished from that species by having the pronotal punctures smaller and more sparsely placed, by having the basal tooth of the front tibiæ more nearly median in position and by having the tarsal claws more deeply cleft.

Diplotaxis volatica Cazier, new species

Small, reddish-brown; upper surface glabrous; labrum broadly, arcuately emarginate; mentum feebly oblique behind, strongly declivous for anterior two-fifths; declivity concave from side to side, posterior margin of declivity arcuate, without raised line or setæ; pronotal angles not impressed; hind femora sparsely punctate between submarginal rows of setigerous punctures; hind coxæ punctate in outer half; pronotum without impressed line along anterior border, anterior angles moderately prominent; tooth of tarsal claws ante-median in position.

Head with large asperate punctures above separated by about one-fourth their own widths, more densely placed along clypeal suture, front evenly rounded; clypeus densely punctate, punctures coalescent at base, clypeal suture entire, nearly straight medially, margins moderately reflexed, anterior and side margins shallowly sinuate medially, anterior angles evenly rounded, canthus angulate subapically. *Pronotum* with side margins subangulate medially, anterior angles prominent; anterior margin not impressed, narrower than posterior margin; surface minutely alutaceous, sparsely punctate, punctures separated by about twice their own widths, median longitudinal impression faint. *Elytra* widest at apical third; humeral umbones prominent; surface strongly alutaceous, costæ distinct, intercostal spaces irregularly punctate, punctures separated by two to three times their own widths, costæ with single row of median punctures. *Undersurface* with very short, sparse, golden pile; anterior and middle legs with tarsi distinctly longer than tibiæ, anterior tibiæ tridentate, basal tooth slightly in front of middle, tarsal claws with inner truncate tooth slightly ante-median in position. Length 8 mm., width 4.3 mm.

Holotype in the writer's collection, taken at Rancho La Golondrina, Rio Sabinas, Muzquiz, Coahuila, Mexico, June 28, 1938 by Rollin H. Baker. One paratopotype in the collection of O. L. Cartwright.

This species is most closely allied to *Diplotaxis bakeri* Cazier but can be separated by its smaller size, reddish-brown color, by the large asperate punctures on the front of the head and by the longer anterior tarsi. From *D. haydenii* Lec. it can be separated by its unimpressed anterior pronotal margin, by the ante-median tooth on the tarsal claws and by the asperate punctures on the head.

Diplotaxis completa Cazier, new species

Rather large, reddish-brown; upper surface glabrous; labrum broadly, arcuately emarginate; mentum strongly declivous at anterior third, margin without raised line, setæ absent at middle; hind femora with sparse irregular punctures between submarginal rows of setigerous punctures, hind coxæ sparsely punctate in outer half; pronotum without impressed line along anterior margin.

Head with larger punctures above separated by about their own widths, more densely placed toward anterior depression, interspaces finely punctate, front above clypeal suture abruptly elevated, surface sparsely punctate, front above slightly impressed; clypeus densely punctate, punctures close set or confluent, clypeal suture narrowly interrupted at middle, margins abruptly, prominently reflexed, side margins nearly straight, anterior margin shallowly sinuate medially, anterior angles evenly rounded, canthi evenly rounded. *Pronotum* widest slightly behind middle, evenly rounded basally, shallowly sinuate apically, anterior angles prominent; anterior margin narrower than basal margin; surface sparsely punctate, large punctures separated by about twice their own widths, interspaces finely punctate. *Elytra* widest at middle; humeral and apical umbones prominent; surface with costæ faint but indicated, intercostal spaces irregularly punctate, punctures separated by about three times their own widths, surface minutely alutaceous, costæ with single, median row of small punctures. *Undersurface* sparsely clothed with short golden pile; anterior tibiæ tridentate, basal tooth slightly in front of middle, hind tarsi longer than tibiæ, tarsal claws with inner tooth slightly ante-median, strongly truncate. Length 12.5 mm., width 6.1 mm.

Holotype in the writer's collection, taken at Serranias del Burro, Coahuila, Mexico, June 18, 1938 by Rollin H. Baker.

This species is most closely allied to *Diplotaxis dentella* Fall and *D. statura* Cazier. It can be distinguished from *D. dentella* by its more widely reflexed clypeal margin, by its evenly rounded canthi, by its more sparsely punctate front, the smooth anterior depression on the front above the clypeal suture, by its less elevated elytral costæ and longer tarsi. From *D. statura* it can be separated by its more widely reflexed anterior clypeal margin, more prominent anterior pronotal angles, by its wider and more densely punctate elytral intercostal areas, more weakly defined costæ, by the presence of the alutaceous elytral sculpturing and the more antemedian tooth of the tarsal claws.

Diplotaxis statura Cazier, new species

Rather large, head black, pronotum cupreous black, elytra dark reddish-brown, shining; upper surface glabrous; labrum broadly, arcuately emarginate; mentum strongly declivous at anterior third, margins without raised line, setæ absent at middle; hind femora with sparse irregular punctures between submarginal rows of setigerous punctures, hind coxæ sparsely punctate in outer half; pronotum without impressed line along anterior margin.

Head with punctures above separated by about their own widths, sparsely punctate along clypeal suture; clypeus with punctures separated by about one-half their own widths, margins shallowly reflexed, side and anterior margins shallowly sinuate medially, clypeal suture entire. *Pronotum* widest at middle, sides nearly straight to base and apex, anterior angles not prominent; anterior margin narrower than posterior; surface shining, sparsely, finely punctate, punctures separated by about twice their own widths, interspaces minutely punctate. *Elytra* widest about middle, humeral and apical umbones prominent; surface shining, costæ distinct, intercostal spaces sparsely punctate, punctures separated by about three times their own widths. *Undersurface* sparsely clothed with short golden pile; anterior tibiæ tridentate, basal tooth slightly ante-median, tarsi longer than tibiæ, inner tooth of tarsal claws median in position, truncate. Length 12 mm., width 6 mm.

Holotype in the writer's collection, taken at Buena Vista, Sierra de la Encantada, Coahuila, Mexico, Elevation 6000 ft., July 7, 1938 by Rollin H. Baker.

Diplotaxis statura Cazier is most closely allied to *D. dentella* Fall and *D. completa* Cazier. It can be separated from *D. dentella* by its shining, less densely punctate elytra, complete clypeal suture, and longer tarsi. From *D. completa* it can be distinguished by its less widely reflexed anterior clypeal margins, less prominent anterior pronotal angles, by its narrower, less densely punctate elytral intercostal spaces, more prominent elytral costæ, by the absence of the alutaceous elytral sculpturing and the median position of the tooth on the tarsal claws.

Diplotaxis cartwrighti Cazier, new species

Medium sized, dark reddish-brown; upper surface glabrous; labrum broadly, arcuately emarginate; mentum feebly oblique behind, strongly declivous for anterior half, declivity concave from side to side, without raised line; thoracic angles not impressed; hind femora nearly impunctate between the submarginal rows of setigerous punctures; tooth of tarsal claws ante-median.

Head with punctures above separated by about their own widths, more densely placed below, front nearly on same plane as clypeus; clypeus densely punctate punctures separated by about one-fourth to one-half their own widths, clypeal suture entire, anterior margin rather deeply sinuate medially, lateral margins shallowly sinuate medially, margins shallowly reflexed. *Pronotum* shining, convex, widest at middle, sides evenly rounded from base to apex, anterior angles not prominent; anterior margin narrower than basal margin; disk with punctures separated by two to three times their own widths. *Elytra* widest about middle, humeral and apical umbones prominent; surface opaque, sericeous; costæ faint but evident, intercostal spaces irregularly punctate, punctures separated by about twice their own widths. *Undersurface* sparsely clothed with short golden pile; anterior tibiæ tridentate, basal tooth slightly ante-median, posterior tarsi equal in length with tibiæ, inner tooth of tarsal claws truncate, ante-median in position. Length 11 mm., width 6 mm.

Holotype in the writer's collection, taken at Tanque de Malone La Babia, Coahuila, Mexico, June 20, 1938, by Rollin H. Baker. One paratype from Serranias del Burro, Coahuila, Mexico, June 18, 1938 (Rollin H. Baker) in the collection of O. L. Cartwright. The writer is pleased to name this species in honor of Mr. Cartwright who made available much of the material herein described.

The paratype specimen has the elytra shining and much less alutaceous than the type. Otherwise, they are similar.

This species is most closely related to *Diplotaxis stabilis* Cazier but can be distinguished from it by its smaller size, convex pronotum, alutaceous elytral sculpturing and longer tarsi.

Diplotaxis stabilis Cazier, new species

Large, dark reddish-brown; upper surface glabrous; labrum broadly, arcuately emarginate; mentum feebly oblique posteriorly, strongly concave from middle to front, without trace of transverse ridge, setæ absent; pronotal angles not impressed; hind femora nearly impunctate between the submarginal rows of setigerous punctures; tooth of tarsal claws post median.

Head irregularly punctate, dense medially and toward clypeus, area immediately posterior to clypeal suture more sparsely punctate, front on same plane as clypeus; clypeus densely punctate, punctures separated by about one-half their own widths or less, clypeal suture entire, anterior and lateral margins moderately reflexed, shallowly sinuate medially, anterior angles evenly rounded, canthi subangulate. *Pronotum* with side margins evenly rounded from base to apex, widest just back of middle, anterior angles somewhat prominent, not impressed behind; disk with punctures separated by about twice their own widths, interspaces minutely punctate. *Elytra* widest at about apical third, humeral and apical umbones prominent; surface shining, costæ rather flat but distinct, intercostal spaces irregularly punctate, punctures separated by two to three times their own widths. *Undersurface* sparsely clothed with short golden pile; anterior tibiæ tridentate, basal tooth slightly in front of middle, posterior femora with few minute punctures between the submarginal rows of setigerous punctures, hind coxæ sparsely punctate in outer half, hind tarsi shorter than tibiæ, tarsal claws with inner tooth strongly truncate, ante-median in position. Length 12.5 mm., width 6.8 mm.

Holotype in the writer's collection, taken at Mesa de la Encontada, Sierra de la Encontada, Elevation 7000 feet, Coahuila, Mexico, July 21, 1938 by Rollin H. Baker.

Most closely allied to *Diplotaxis belfragei* Fall but distinguishable from it by its less angulate side pronotal margins, smaller punctures throughout, shorter tarsi and by the more ante-median tooth of the tarsal claws.

PSYCHE

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